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# INFLUENCE OF INTERPHASE BASED ON ISOCYANATES AT STARCH SURFACE AND OBSERVING THE APPLICATION IN VULCANIZATES

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**ABSTRACT:** The influence of isocyanates (PIK – phenylisocyanate, MDI – metyldiisocyanate) is inspected as an interphase by means of selected natural polysacharides (starch) in vulcanizated butadiene and styrene-butadiene rubber compounds. By modification of the starch surface we have created an interphase between the polymer matrix and filler particle, and we also achieved improvements in physical-mechanical properties. When gradually increasing the PIK concentration in modification solution, we observed the increase of tensile strength by vulcanized specimens. By modification with MDI we improved the physical-mechanical properties, but with the further increase of the modificator's concentration we observed a decrease of physical-mechanical properties.

**KEY WORDS:** interphase, polymer matrix, filler, surface, polar-nonpolar, modification

## 1. INTRODUCTION

Incorporation of most of the common fillers into the polymeric matrix is difficult, because of its own polaric character and on the other side because of nonpolaric character of polymeric matrix. This is the reason for further modification of filler's surface to the more nonpolaric one. The filler's surface could be changed by creation of interphase. The interphase consists of two different parts. The one which is close to filler has hydrofilic character and the one next to polymeric matrix has hydrofobic character. Interphase works as connecting element between those two different surfaces and creates transition environment between them. Interphase ensures higher tenacity limit and of course, based on that, better physical-mechanical compound properties.

## 2. FORMATTING

### 2.1 Applies surface modificator

PIK - Phenylisoicyanate
Molecular weight: Mr = 119.12 g/mol
Density = 1093 - 1095 kg/m$^3$
Boil Temperature = 165 °C

MDI – 1,4-methyldiphenyldiisocyanate
Molecular weight: Mr = 252.24 g/mol
Melting point = 38.9 °C

Surface modificators MDI and PIK were observed acting as an interphase at the surface of a filler (starch) and they influenced physical-mechanical properties of filled Butadiene and of Butadiene-Styrene rubber compound.

Following figures were observed:

- tensile strength
- tensile
- Module 100, 200, 300

### 2.2 Modification conditions and processes

1. Drying at vacuum conditions (30 min, 60 °C)
2. Reaction with modification solution (60 min, 55 °C)
3. Extraction of modification solution
4. Drying the filler

### 2.3 Formulations of modification solutions

**Tab. 1:** Formulation of modification solutions

| | Filler | Modification Solution |
|---|---|---|
| PIK 0.25% | Starch - 60g | 119.7 ml PetrolEther + 0.3 ml MDI + 0.3 ml N-methyl diethanolamin |
| PIK 0.5% | Starch - 60g | 119.4 ml PetrolEther + 0.6 ml MDI + 0.3 ml N-methyl diethanolamin |
| PIK 1% | Starch - 60g | 118.8 ml PetrolEther + 1.2 ml MDI + 0.3 ml N-methyl diethanolamin |
| PIK 2% | Starch - 60g | 117.6 ml PetrolEther + 2.4 ml MDI + 0.3 ml N-methyl diethanolamin |
| MDI 0.25% | Starch - 60g | 119.7 ml PetrolEther + 0.3 ml MDI + 0.3 ml N-methyl diethanolamin |
| MDI 0.5% | Starch - 60g | 119.4 ml PetrolEther + 0.6 ml MDI + 0.3 ml N-methyl diethanolamin |
| MDI 1% | Starch - 60g | 118.8 ml PetrolEther + 1.2 ml MDI + 0.3 ml N-methyl diethanolamin |
| MDI 2% | Starch - 60g | 117.6 ml PetrolEther + 2.4 ml MDI + 0.3 ml N-methyl diethanolamin |

### 2.4 Formulations of rubber compound filled with modified and non-modified starch

**Tab. 2:** Formulation of rubber compounds

| **I. step** | **dsk** |
|---|---|
| Styrene Butediene Rubber | 80 |
| Butadiene Rubber | 20 |
| Filler - Starch | 80 |
| ZnO | 1.5 |
| Stearic acid | 1 |
| **II. Step** | |
| Sulphur | 1 |
| CBS | 0.5 |

Compounds were prepared by using Plasti-Corder Brabender with cavity volume of 70 $cm^3$, with constant rpm of 70 per min. and temperature 120 °C in I. step and 85 °C in II. step.
Vulcanization conditions – 150 °C, 20 MPa (time depends on reometer curve)

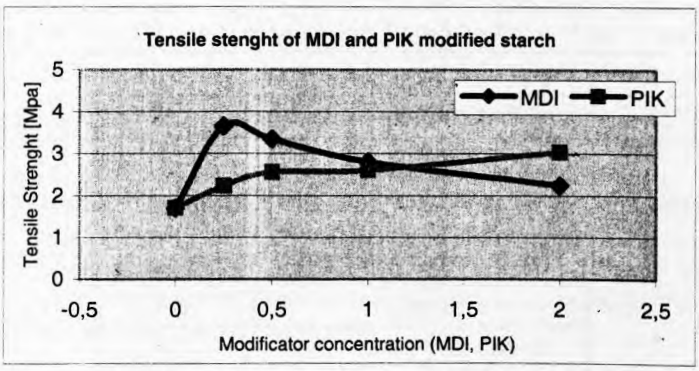
## 3. RESULTS

**Tab. 3:** Physical-mechanical properties of vulcanized rubber compounds filled with MDI modified and non-modified starch

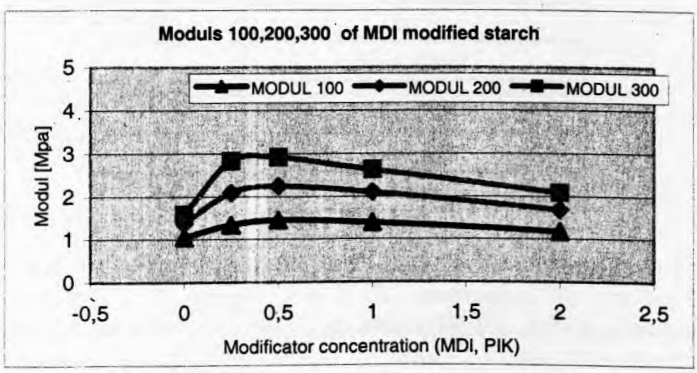
| | Tensile strength [MPa] | Tensile [%] | Module 100 [MPa] | Module 200 [MPa] | Module 300 [MPa] |
|---|---|---|---|---|---|
| pure starch | 1.700 | 695 | 1.052 | 1.373 | 1.582 |
| MDI 0.25% | 3.655 | 503 | 1.338 | 2.091 | 2.830 |
| MDI 0.5% | 3.357 | 442 | 1.448 | 2.251 | 2.925 |
| MDI 1% | 2.812 | 483 | 1.392 | 2.105 | 2.631 |
| MDI 2% | 2.251 | 512 | 1.174 | 1.680 | 2.089 |

**Tab. 4:** Physical-mechanical properties of vulcanized rubber compounds filled with PIK modified and non-modified starch

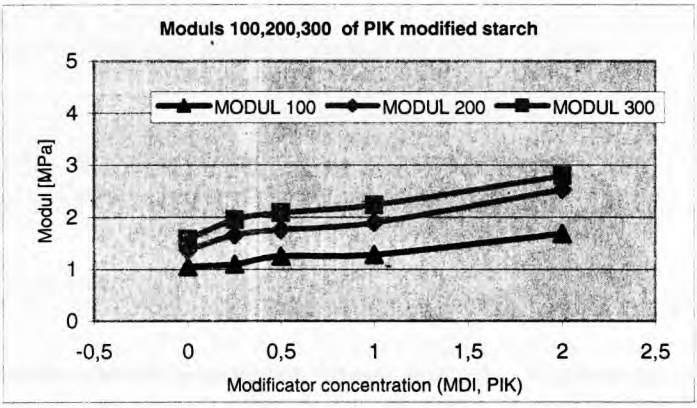
| | Tensile strength [MPa] | Tensile [%] | Module 100 [MPa] | Module 200 [MPa] | Module 300 [MPa] |
|---|---|---|---|---|---|
| pure starch | 1.700 | 695 | 1.052 | 1.373 | 1.582 |
| PIK 0.25% | 2.231 | 752 | 1.101 | 1.658 | 1.953 |
| PIK 0.5% | 2.56 | 859 | 1.256 | 1.766 | 2.089 |
| PIK 1% | 2.604 | 780 | 1.29 | 1.901 | 2.241 |
| PIK 2% | 3.039 | 604 | 1.689 | 2.534 | 2.799 |




**Graph 1:** Tensile strength of MDI and PIK modified starch




**Graph 2:** Moduls 100, 200, 300 of MDI surface modified starch




**Graph 3:** Moduls 100, 200, 300 of PIK surface modified starch

## 4. CONCLUSIONS

- By using MDI (1,4-methyldiphenyldiisocyanate) and PIK (phenylisoicyanate) as an interphase, we have achieved the modification of filler's surface and improved some physical-mechanical properties of filled vulcanized rubber compounds.
- By modification of starch surface with MDI, we have created an interphase which improved the tensile strength by using small concentrations of the modificator. When using a higher concentration of MDI we have observed the decrease of the tensile strength, because MDI has two functional isocyanate groups which could crosslink modified filler.
- By modification of starch surface with PIK, we have created an interphase and we observed an increase of the tensile strength. The increase depends on the modificator's concentration.

## 5. REFERENCES

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